

**NIST TIME AND FREQUENCY BULLETIN  
NIST IR 6658-01**

**No. 625 January 2010**

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This bulletin is published monthly. Address correspondence to:

Eyvon M. Petty, Editor  
Time and Frequency Division  
National Institute of Standards and Technology  
325 Broadway  
Boulder, CO 80305-3328  
(303) 497-3295  
Email: [pettye@boulder.nist.gov](mailto:pettye@boulder.nist.gov)



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U.S. DEPARTMENT OF COMMERCE, GARY LOCKE, Secretary  
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY, Patrick D. Gallagher, Director

## 1. GENERAL BACKGROUND INFORMATION

### ACRONYMS AND ABBREVIATIONS USED IN THIS BULLETIN

ACTS	- Automated Computer Time Service		
BIPM	- Bureau International des Poids et Mesures		
CS	- Cesium Standard		
GPS	- Global Positioning System		
IERS	- International Earth Rotation Service		
LORAN	- Long Range Navigation		
MC	- Master Clock		
MJD	- Modified Julian Date		
NIST	- National Institute of Standards and Technology		
NOAA	- National Oceanic and Atmospheric Administration		
NVLAP	- National Voluntary Laboratory Accreditation Program	ns	- nanosecond
SI	- International System of Units	μs	- microsecond
TA	- Atomic Time	ms	- millisecond
TAI	- International Atomic Time	s	- second
USNO	- United States Naval Observatory	min	- minute
UTC	- Coordinated Universal Time		

## 2. TIME SCALE INFORMATION

The values listed below are based on data from the IERS, the USNO, and NIST. The UTC(USNO,MC) - UTC(NIST) values are averaged measurements from all available common-view GPS satellites (see bibliography on page 5). UTC - UTC(NIST) data are on page 3.

0000 HOURS COORDINATED UNIVERSAL TIME			
Dec 2009	MJD	UT1-UTC(NIST) (±5 ms)	UTC(USNO,MC) - UTC(NIST) (±20 ns)
3	55168	141 ms	19 ns
10	55175	133 ms	18 ns
17	55182	127 ms	18 ns
24	55189	120 ms	16 ns
31	55196	114 ms	13 ns

The master clock pulses used by the WWV, WWVH, and WWVB time-code transmissions are referenced to the UTC(NIST) time scale. Occasionally, 1 s is added to the UTC time scale. This second is called a leap second. Its purpose is to keep the UTC time scale within ±0.9 s of the UT1 astronomical time scale, which changes slightly due to variations in the Earth's period of rotation.

**NOTE:** No leap second was added at the end of December 2009.

Positive leap seconds, beginning at 23 h 59 min 60 s UTC and ending at 0 h 0 min 0 s UTC, were inserted in the UTC time scale on 30 June 1972, 1981-1983, 1985, 1992-1994, and 1997, and on 31 December 1972-1979, 1987, 1989, 1990, 1995, 1998, 2005, and 2008.

The use of leap seconds ensures that UT1 - UTC will always be held within ±0.9 s. The current value of UT1 - UTC is called the DUT1 correction. DUT1 corrections are broadcast by WWV, WWVH, WWVB, and ACTS and are printed below. These corrections may be added to received UTC time signals in order to obtain UT1.

	+0.1 s beginning 0000 UTC 12 November 2009
	+0.2 s beginning 0000 UTC 11 June 2009
	+0.3 s beginning 0000 UTC 12 March 2009
DUT1 = UT1 - UTC =	-0.6 s beginning 0000 UTC 20 November 2008
	-0.5 s beginning 0000 UTC 07 August 2008

The difference between UTC(NIST) and UTC has been within  $\pm 100$  ns since July 6, 1994. The table below shows values of UTC - UTC(NIST) as supplied by the BIPM in their *Circular T* publication for the most recent 310-day period in which data are available. Data are given at 10-day intervals. Five-day interval data are available in *Circular T*.

0000 Hours Coordinated Universal Time		
DATE	MJD	UTC-UTC(NIST) ns
Nov. 24, 2009	55159	15.6
Nov. 14, 2009	55149	14.1
Nov. 04, 2009	55139	7.8
Oct. 25, 2009	55129	3.9
Oct. 15, 2009	55119	0.6
Oct. 05, 2009	55109	-5.2
Sep. 25, 2009	55099	-10.2
Sep. 15, 2009	55089	-13.8
Sep. 05, 2009	55079	-15.1
Aug. 26, 2009	55069	-15.8
Aug. 16, 2009	55059	-16.4
Aug. 06, 2009	55049	-14.7
Jul. 27, 2009	55039	-12.3
Jul. 17, 2009	55029	-9.6
Jul. 07, 2009	55019	-4.9
Jun. 27, 2009	55009	0
Jun. 17, 2009	54999	4.7
Jun. 07, 2009	54989	5.7
May 28, 2009	54979	10.3
May 18, 2009	54969	11.2
May 08, 2009	54959	10.8
Apr. 28, 2009	54949	9.7
Apr. 18, 2009	54939	7.0
Apr. 08, 2009	54929	10.0
Mar. 28, 2009	54919	7.5
Mar. 18, 2009	54909	7.1
Mar. 08, 2009	54899	4.9

### 3. PHASE DEVIATIONS FOR WWVB AND LORAN-C

WWVB - The values shown for WWVB are the time differences between the time markers of the UTC(NIST) time scale and the first positive-going zero voltage crossover measured at the transmitting antenna. The uncertainty of the individual measurements is  $\pm 0.5 \mu\text{s}$ . The values listed are for 1300 UTC.

LORAN-C - The values shown for LORAN-C represent the daily accumulated phase shift. The phase shift is measured by comparing the output of a LORAN receiver to the UTC(NIST) time scale for a period of 24 h. If data were not recorded on a particular day, the symbol (-) is printed. The stations monitored are Baudette, Minnesota (8970) and Boise City, Oklahoma (9610). The monitoring is done from the NIST laboratories in Boulder, Colorado.

**Note: The values shown for LORAN-C are in nanoseconds.**

DATE	MJD	UTC(NIST)-WWVB (60 kHz)		
		ANTENNA PHASE ( $\mu\text{s}$ )	UTC(NIST) - LORAN PHASE (ns)	
			LORAN-C (BAUDETTE) (8970)	LORAN-C (BOISE CITY) (9610)
12/01/2009	55166	5.65	-11	+8
12/02/2009	55167	5.65	+20	+60
12/03/2009	55168	5.65	+119	+11
12/04/2009	55169	5.65	+74	-6
12/05/2009	55170	5.65	+2	+27
12/06/2009	55171	5.65	+44	+24
12/07/2009	55172	5.65	-46	+23
12/08/2009	55173	5.65	+6	+22
12/09/2009	55174	5.65	+35	-43
12/10/2009	55175	5.65	-46	+0
12/11/2009	55176	5.65	+199	-10
12/12/2009	55177	5.65	-51	-27
12/13/2009	55178	5.65	-104	-8
12/14/2009	55179	5.65	-103	+2
12/15/2009	55180	5.65	-87	-8
12/16/2009	55181	5.65	-18	-11
12/17/2009	55182	5.65	-158	-1
12/18/2009	55183	5.65	+74	+11
12/19/2009	55184	5.65	-38	+23
12/20/2009	55185	5.65	+31	-17
12/21/2009	55186	5.65	-19	+5
12/22/2009	55187	5.65	+18	-7
12/23/2009	55188	5.65	-97	+7
12/24/2009	55189	5.65	+7	+50
12/25/2009	55190	5.65	+65	0
12/26/2009	55191	5.65	+113	-27
12/27/2009	55192	5.65	-16	-1
12/28/2009	55193	5.65	-22	-6
12/29/2009	55194	5.65	-63	-33
12/30/2009	55195	5.65	-26	+13
12/31/2009	55196	5.65	-6	+4

#### 4. BROADCAST OUTAGES OVER FIVE MINUTES AND WWVB PHASE PERTURBATIONS

OUTAGES OF 5 MINUTES OR MORE						PHASE PERTURBATIONS 2 ms			
Station	Dec 2009	MJD	Began UTC	Ended UTC	Freq.	Dec 2009	MJD	Began UTC	End UTC
WWVB					60 kHz				
WWV									
WWVH									

#### 5. NOTES ON NIST TIME SCALES AND PRIMARY STANDARDS

Primary frequency standards developed and operated by NIST are used to provide accuracy (rate) input to the BIPM. NIST-F1, a cold-atom cesium fountain frequency standard, has served as the U.S. primary time and frequency standard since 1999. The uncertainty of NIST-F1 is currently about 3 parts in  $10^{16}$ .

The AT1 scale is run in real-time by use of data from an ensemble of cesium standards and hydrogen masers. It is a free-running scale whose frequency is maintained as nearly constant as possible by choosing the optimum weight for each clock that contributes to the computation.

UTC(NIST) is generated as an offset from our real-time scale AT1. It is steered in frequency towards UTC by use of data published by the BIPM in its *Circular T*. Changes in the steering frequency will be made, if necessary, at 0000 UTC on the first day of the month, and occasionally at mid-month. A change in frequency is limited to no more than  $\pm 2$  ns/day. The frequency of UTC(NIST) is kept as stable as possible at other times.

UTC is generated at the BIPM by use of a post-processed time-scale algorithm and is not available in real-time. The parameters that we use to generate UTC(NIST) in real-time are therefore based on an extrapolation of UTC from the most recent available data.

#### 6. BIBLIOGRAPHY

Allan, D.W.; Hellwig, H.; and Glaze, D.J., "An accuracy algorithm for an atomic time scale," *Metrologia*, Vol.11, No.3, pp. 133-138 (1975).

Allan, D.W.; Davis, D.D.; Weiss, M.A.; Clements, A.; Guinot, B.; Granveaud, M.; Dorenwendt, K.; Fischer, B.; Hetzel, P.; Aoki, S.; Fujimoto, M.; Charron, L.; and Ashby, N., "Accuracy of international time and frequency comparisons via global positioning system satellites in common-view," *IEEE Transactions on Instrumentation and Measurement*, Vol. IM-34, pp.118-125 (1985).

Heavner, T.P.; Jefferts, S.R.; Donley, E.A.; Shirley, J.H. and Parker, T.E., "NIST F1; recent improvements and accuracy evaluations," *Metrologia*, Vol. 42, pp. 411-422 (2005).

Jefferts, S.R.; Shirley, J.; Parker, T.E.; Heavner, T.P.; Meekhof, D.M.; Nelson, C., Levi, F.; Costanza, G.; De Marchi, A.; Drullinger, R.; Hollberg, L.; Lee, W.D.; and Walls, F.L., "Accuracy evaluation of NIST-F1," *Metrologia*, Vol. 39, pp. 321-336 (2002).

Lewandowski, W. and Thomas, C., "GPS Time transfer," *Proceedings of the IEEE*, Vol. 79, pp. 991-1000 (1991).

Parker, T.E.; Jefferts, S.R.; Heavner, T.P.; and Donley, E.A., "Operation of the NIST-F1 caesium fountain primary frequency standard with a maser ensemble, including the impact of frequency transfer noise," *Metrologia*, Vol. 42, pp. 423-430 (2005).

Weiss, M.A.; Allan, D.W., "An NBS Calibration Procedure for Providing Time and Frequency at a Remote Site by Weighting and Smoothing of GPS Common View Data," *IEEE Transactions on Instrumentation and Measurement*, Vol. IM-36, pp. 572-578 (1987).

Table 7.1 lists parameters that are used to define UTC(NIST) with respect to our real-time scale AT1. To find the value of UTC(NIST) - AT1 at any time T (expressed as a Modified Julian Day, including a fraction if needed), the appropriate equation to use is the one for which the desired T is greater than or equal to the entry in the  $T_0$  column and less than the entry in the last column. The values of  $x_{ls}$ , x, and y for that month are then used in the equation below to find the desired value. The parameters x and y represent the offsets in time and frequency, respectively, between UTC(NIST) and AT1; the parameter  $x_{ls}$  is the number of leap seconds applied to both UTC(NIST) and UTC, as specified by the IERS. Leap seconds are not applied to AT1.

Table 7.1 UTC(NIST) - AT1 = $x_{ls} + x + y*(T - T_0)$					
Month	$x_{ls}$ (s)	x (ns)	y (ns/d)	$T_0$ (MJD)	Valid until 0000 on: (MJD)
Feb 10	-34	-344624.3	-38.0*	55228	55256
Jan 10	-34	-343446.3	-38.0	55197	55228
Dec. 09	-34	-342952.3	-38.0	55184	55197
Dec. 09	-34	-342261.1	-38.4	55166	55184†
Nov 09	-34	-341838.7	-38.4	55155	55166
Nov 09	-34	-341101.5	-38.8	55136	55155†
Oct 09	-34	-340441.9	-38.8	55119	55136
Oct 09	-34	-339895.9	-39.0	55105	55119†
Sep 09	-34	-339271.9	-39.0*	55089	55105
Sep 09	-34	-338730.1	-38.7	55075	55089†
Aug 09	-34	-337917.4	-38.7	55054	55075
Aug 09	-34	-337534.4	-38.3	55044	55054†
Jul 09	-34	-336691.8	-38.3	55022	55044
Jul 09	-34	-336349.8	-38.0	55013	55022†
Jun 09	-34	-335209.8	-38.0	54983	55013
May 09	-34	-334791.8	-38.0	54972	54983
May 09	-34	-334027.8	-38.2	54952	54972†
Apr 09	-34	-333225.6	-38.2	54931	54952
Apr 09	-34	-332880.9	-38.3	54922	54931†
Mar 09	-34	-331693.6	-38.3	54891	54922
Feb 09	-34	-330621.2	-38.3	54863	54891

† Rate change in mid-month

\*Provisional value